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**Tessari et al.**

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(54) **METHOD AND APPARATUS FOR DRILLING A BOREHOLE WITH A BOREHOLE LINER**

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(73) Assignee: **Tesco Corporation**, Calgary (CA)

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Apr. 17, 2003 (CA) ..... 2429076

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***E21B 7/26*** (2006.01)

(52) **U.S. Cl.** ..... **175/21**; 175/38; 175/72; 175/234; 175/318; 175/324

(58) **Field of Classification Search** ..... None
See application file for complete search history.

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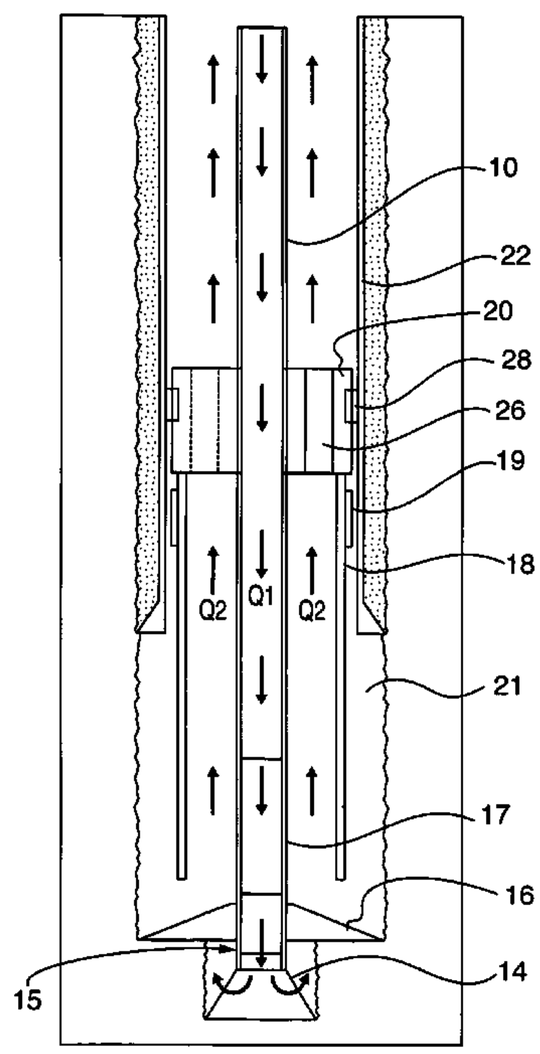
(57) **ABSTRACT**

A method for drilling a borehole includes; providing a drill string of drill pipe including a center bore, a distal end, a bit assembly at the distal end; hanging a liner from the drill string, thereby forming an annular space between the drill string and the liner and with the bit assembly extending from a lower end of the liner; positioning the drill string with the liner attached thereto in a borehole such that a second annular space is formed between the liner and the borehole wall; operating the bit assembly to proceed with drilling the borehole; and circulating drilling fluid down through the center bore of the drill string out through the bit assembly and down through the second annular space between the liner and the borehole wall, the drilling fluid returning up through the annular space between the drill string and the liner.

**32 Claims, 10 Drawing Sheets**



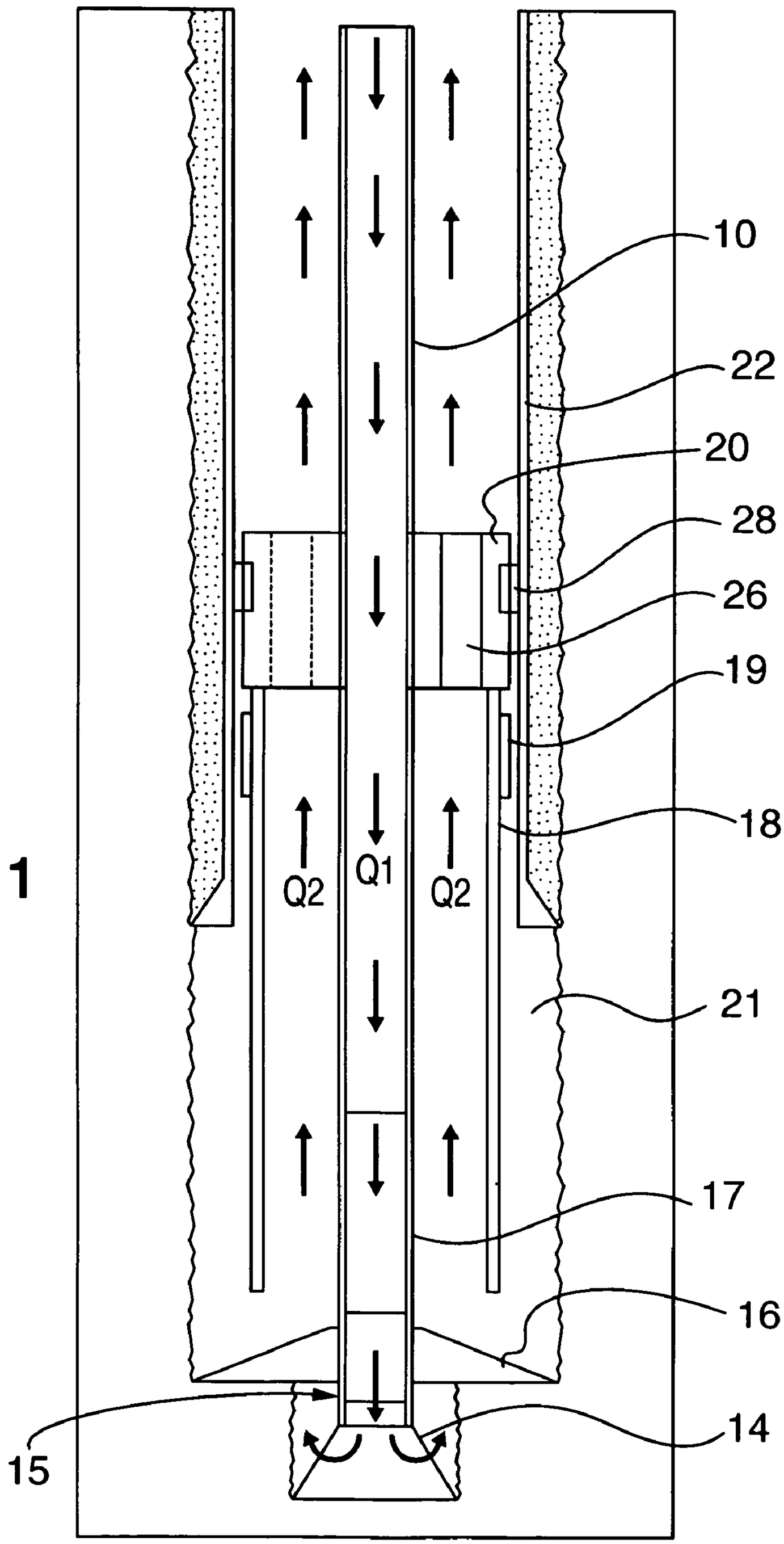



FIG. 1

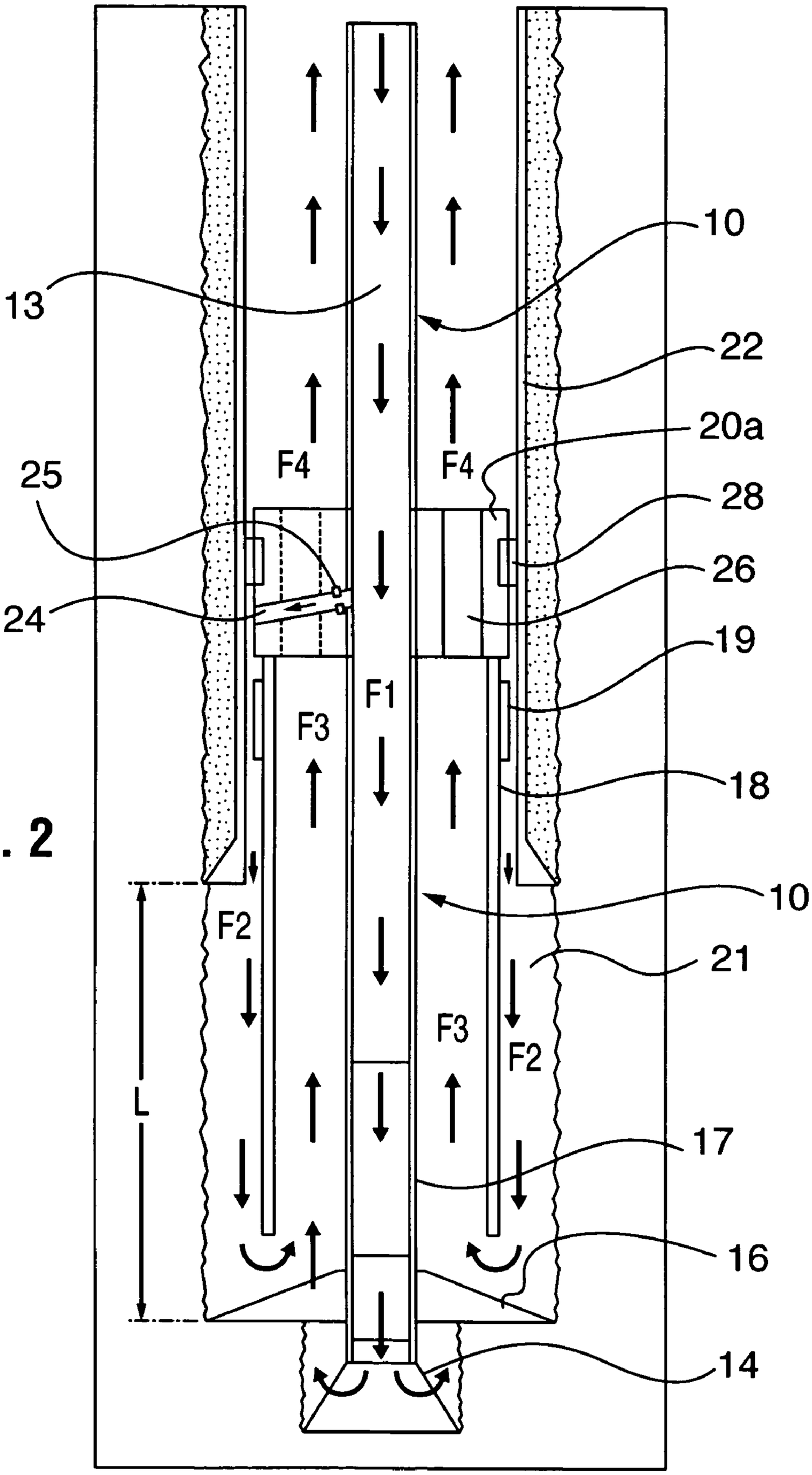



FIG. 2

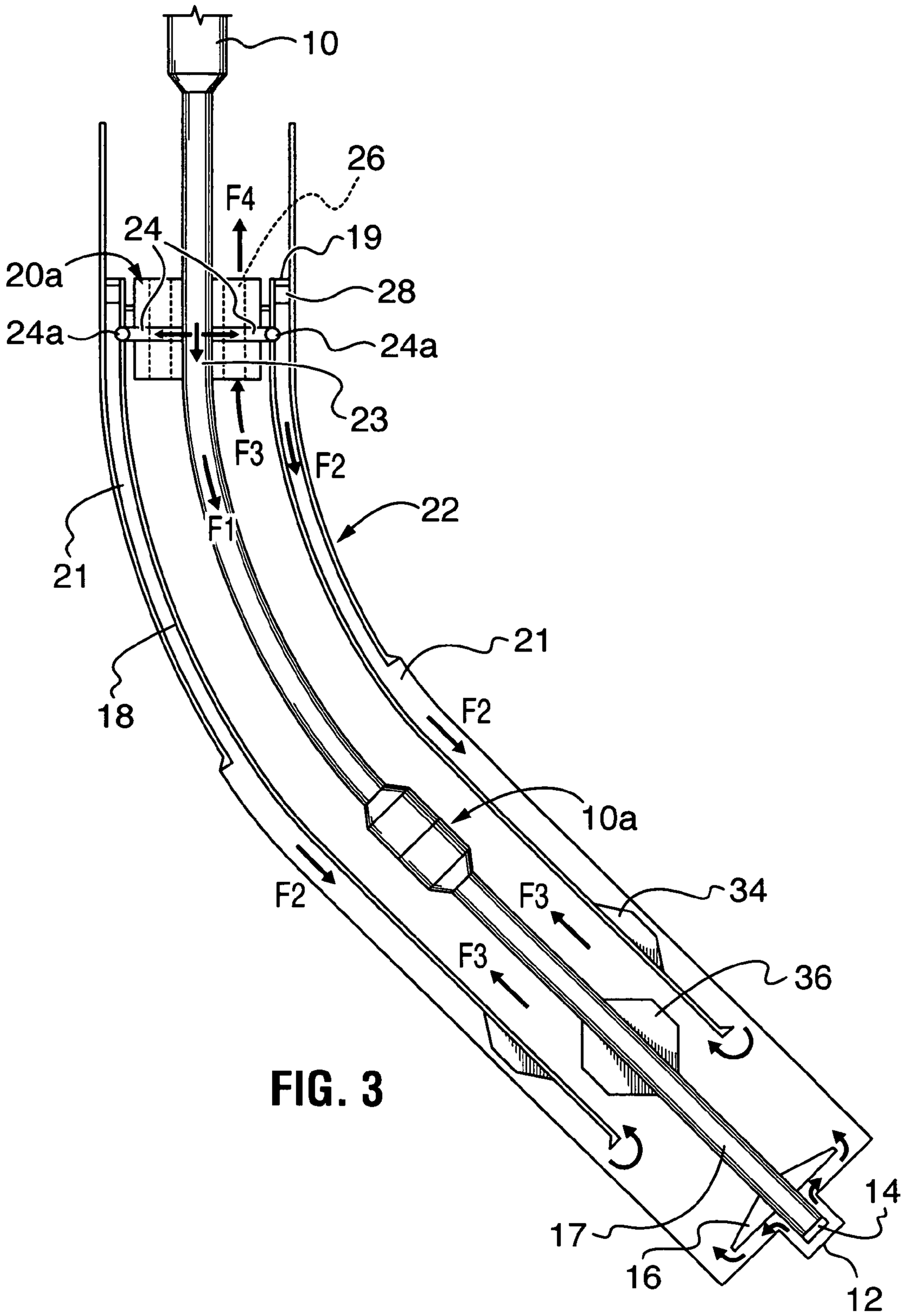

10
26
F4
24
19
20a
28
24a
24a
23
F3
F2
F1
22
21
21
18
F2
10a
F2
F3
34
F3
36
14
17
16
12

FIG. 3

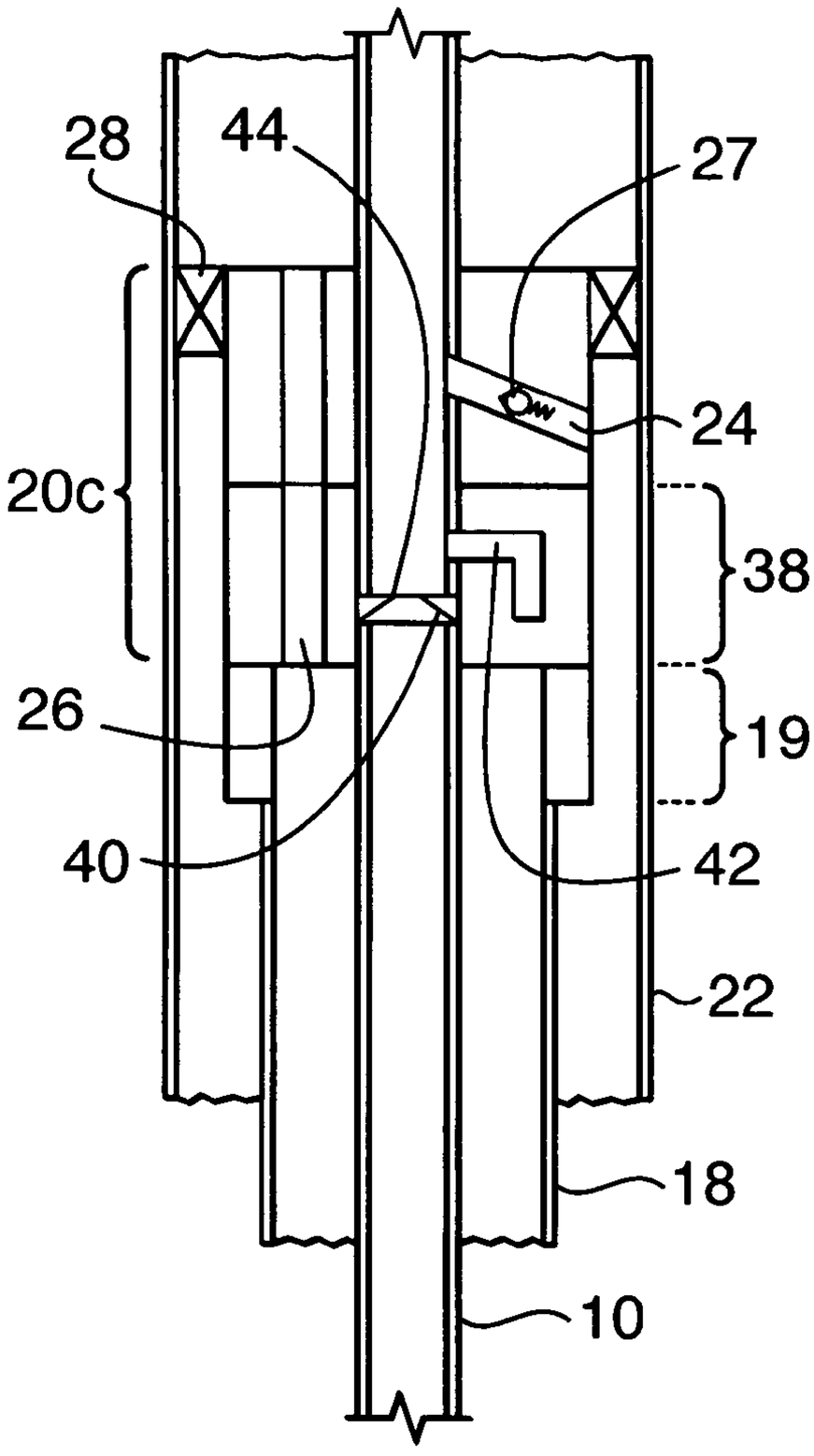

28
44
27
24
20c
38
26
19
40
42
22
18
10

FIG. 4

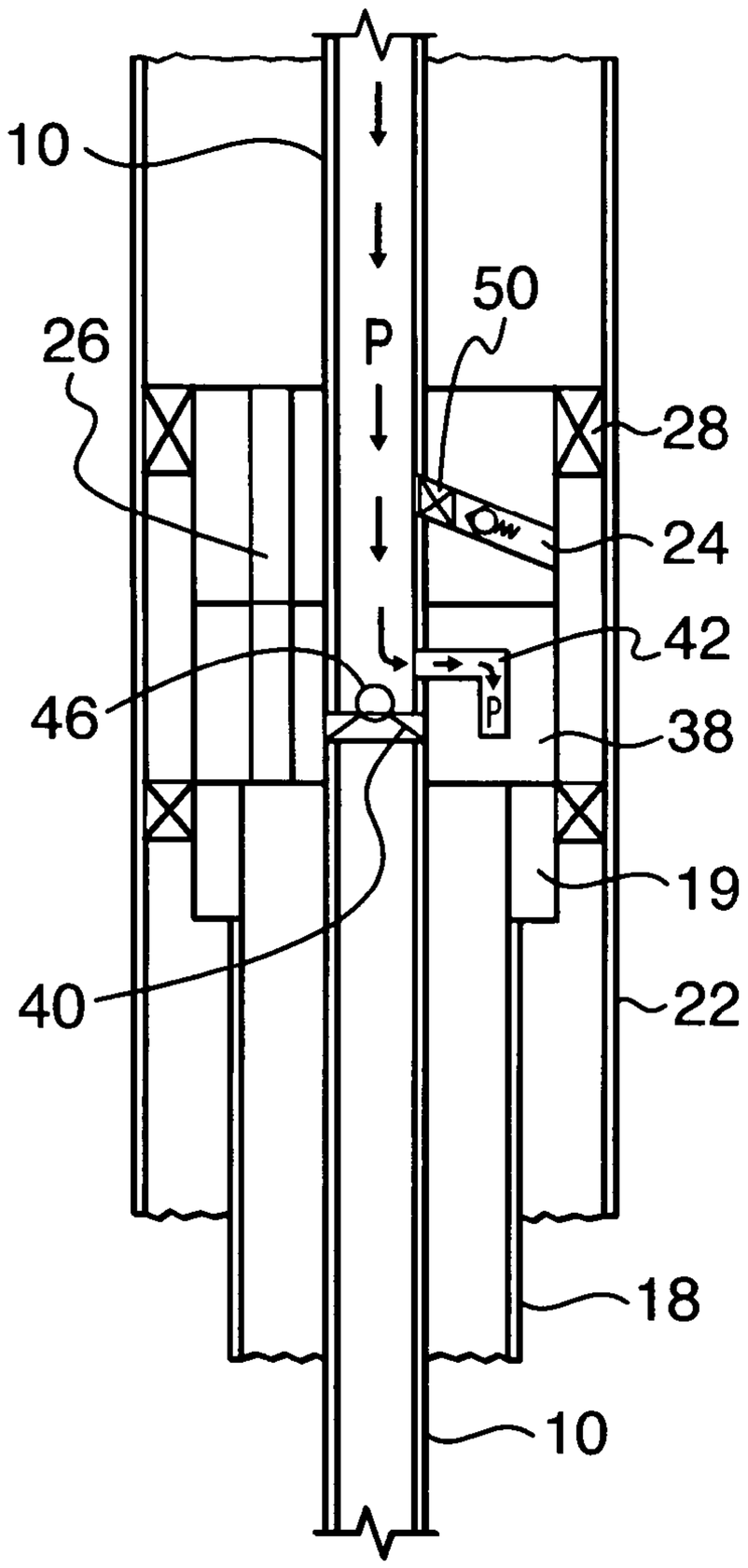

10
P
50
26
28
24
42
46
P
38
19
40
22
18
10

FIG. 5

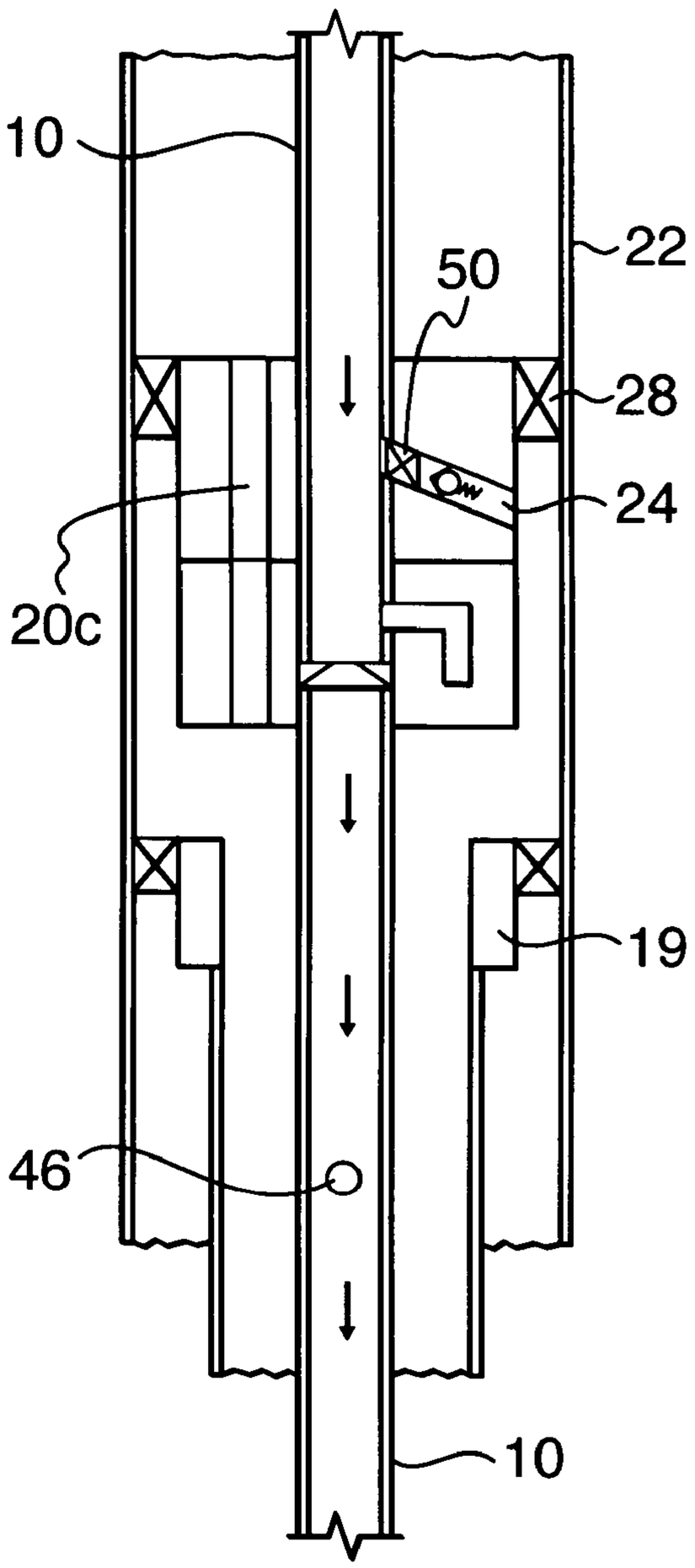



FIG. 6

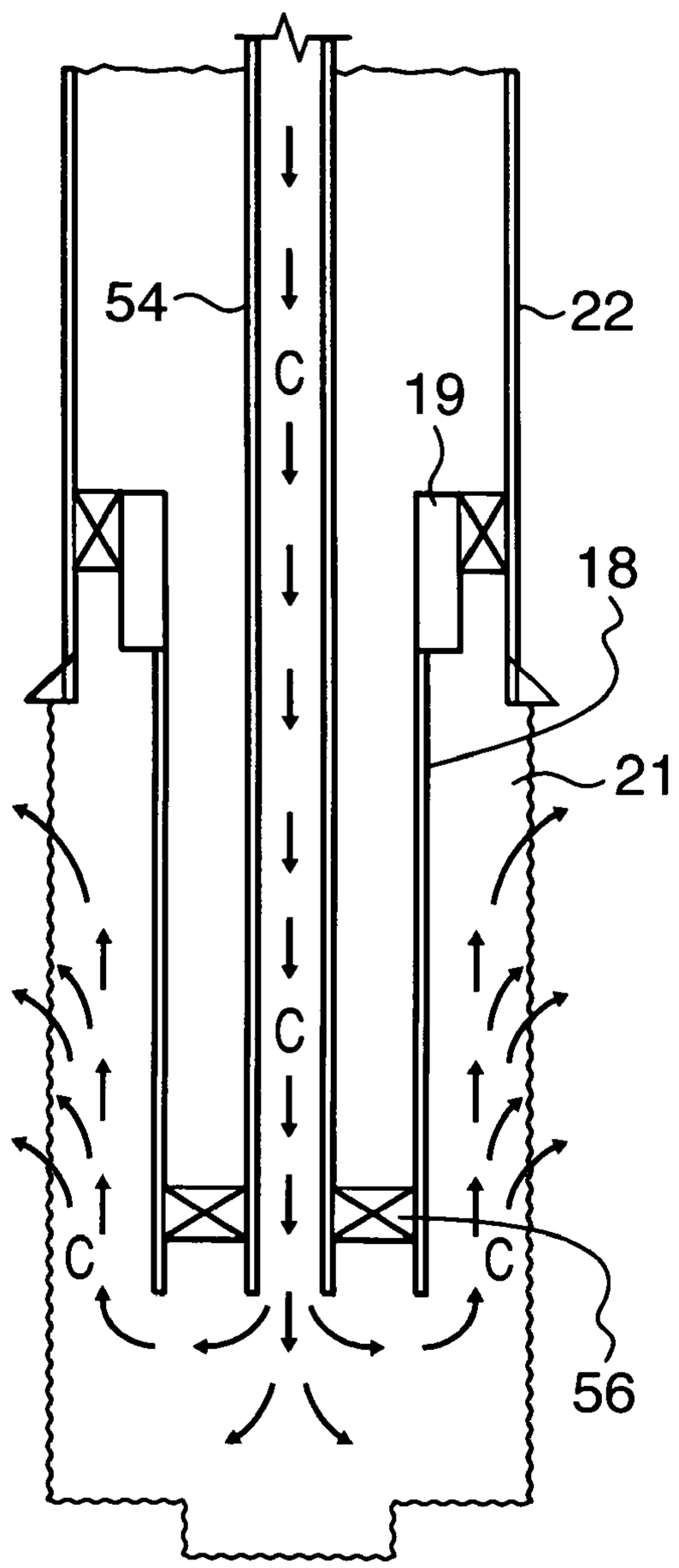



FIG. 7

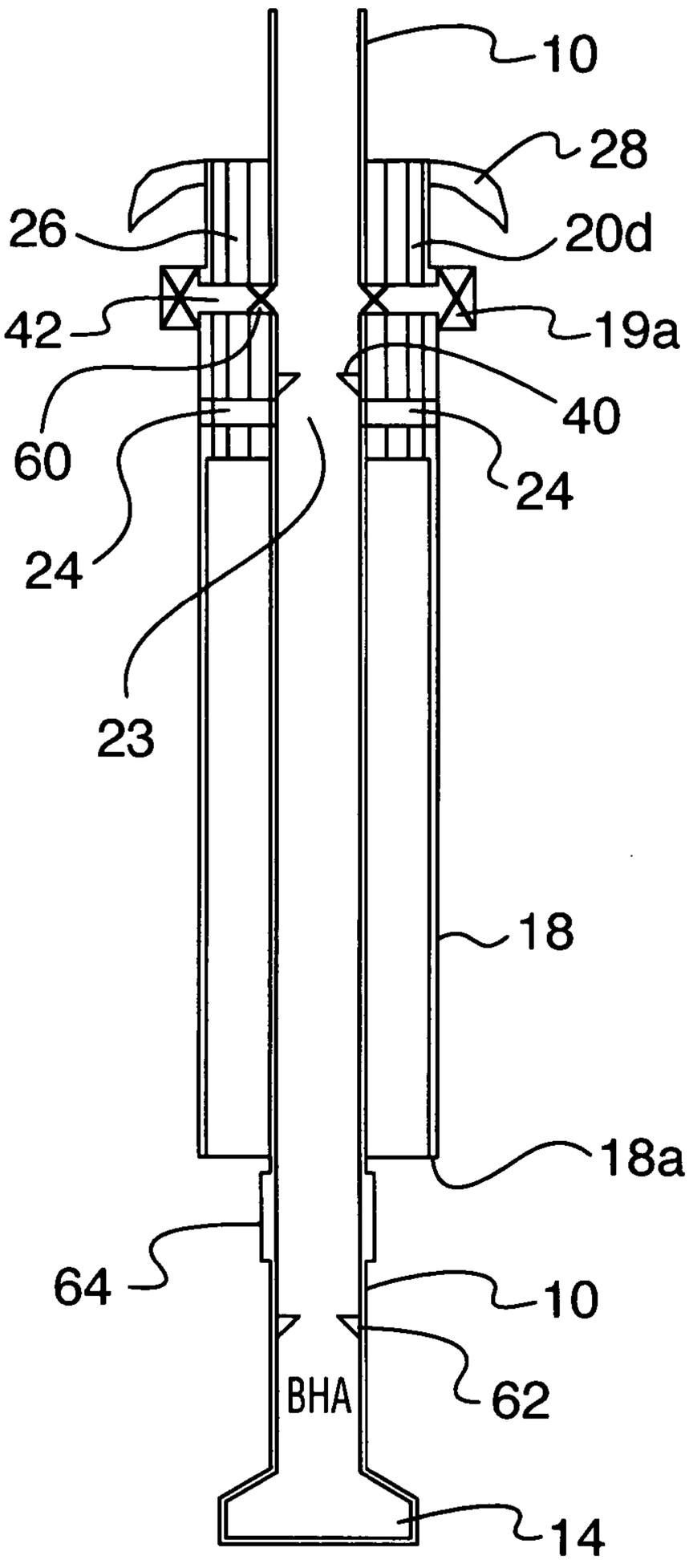

10
28
26
20d
42
19a
40
60
24
24
23
18
18a
64
10
62
BHA
14

FIG. 8

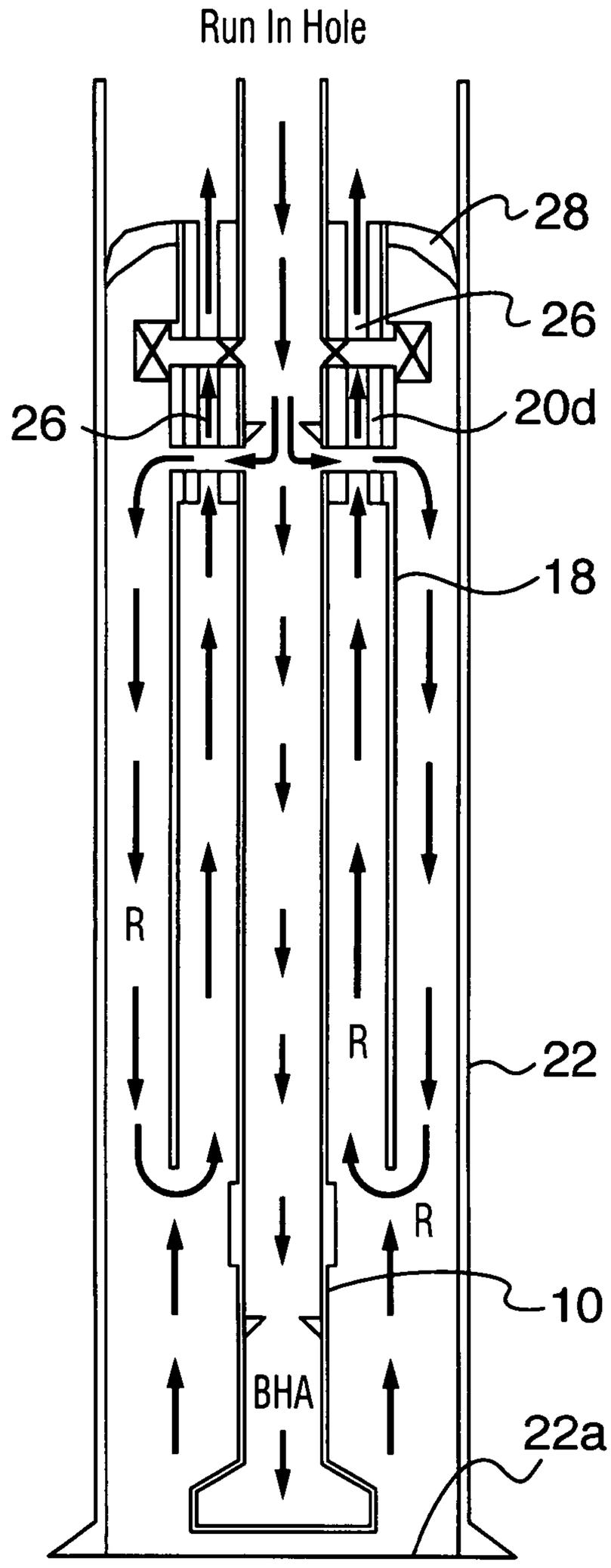

Run In Hole
28
26
20d
26
18
R
R
22
R
10
BHA
22a

FIG. 9

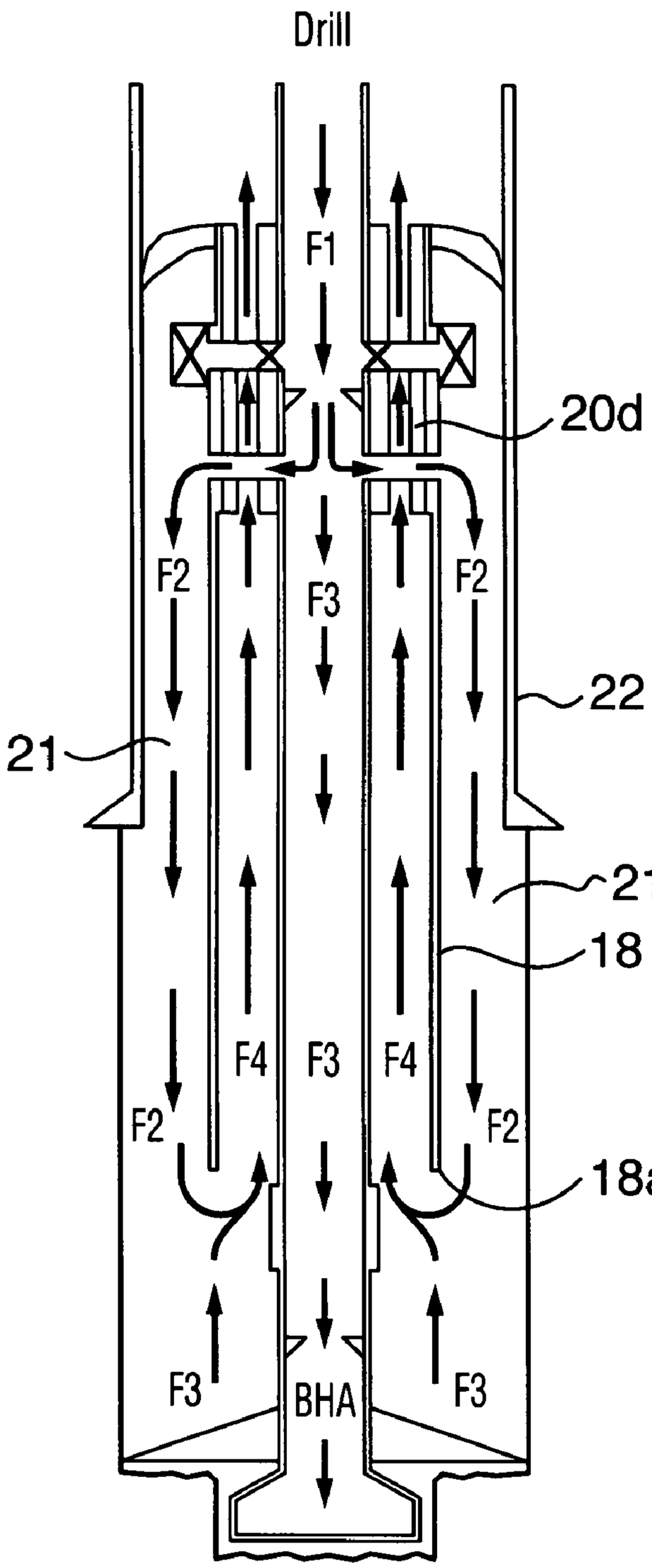

Drill
F1
20d
F2
F3
F2
22
21
21
18
F4
F3
F4
F2
F2
18a
F3
BHA
F3

FIG. 10

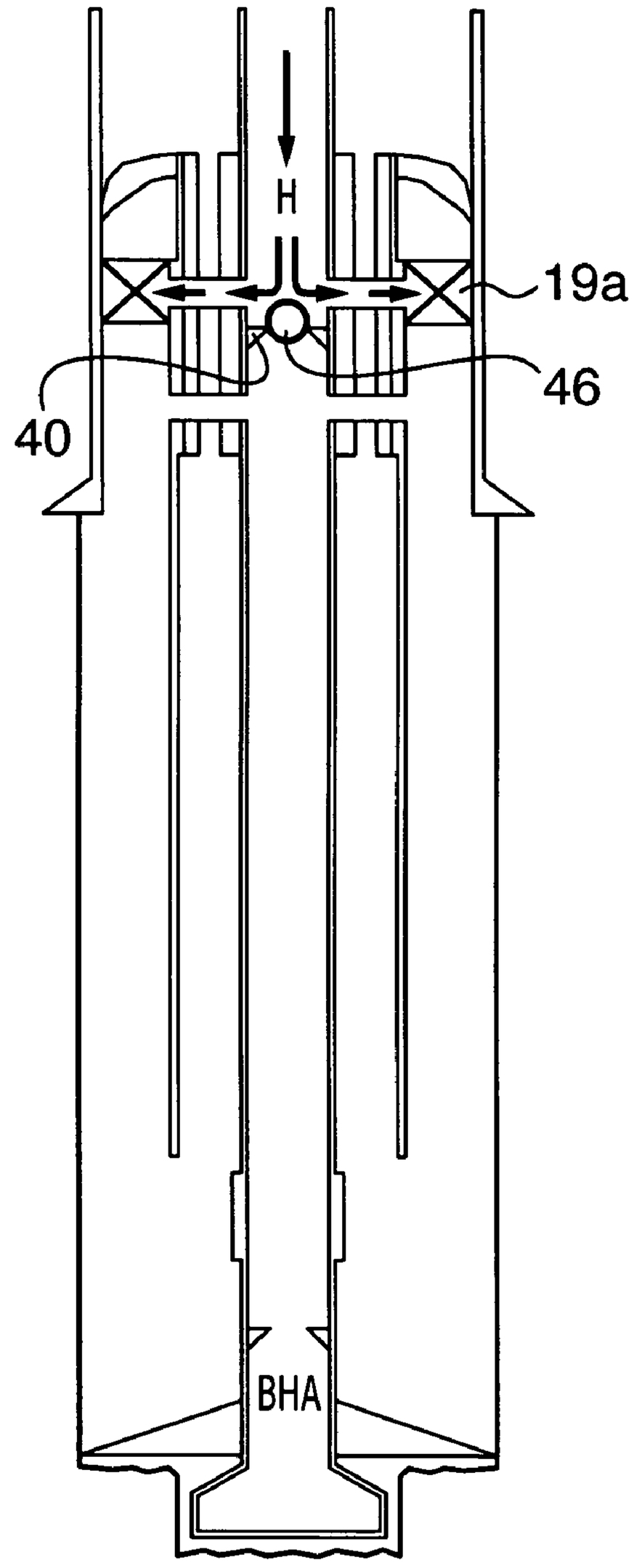

H
19a
46
40
BHA

FIG. 11

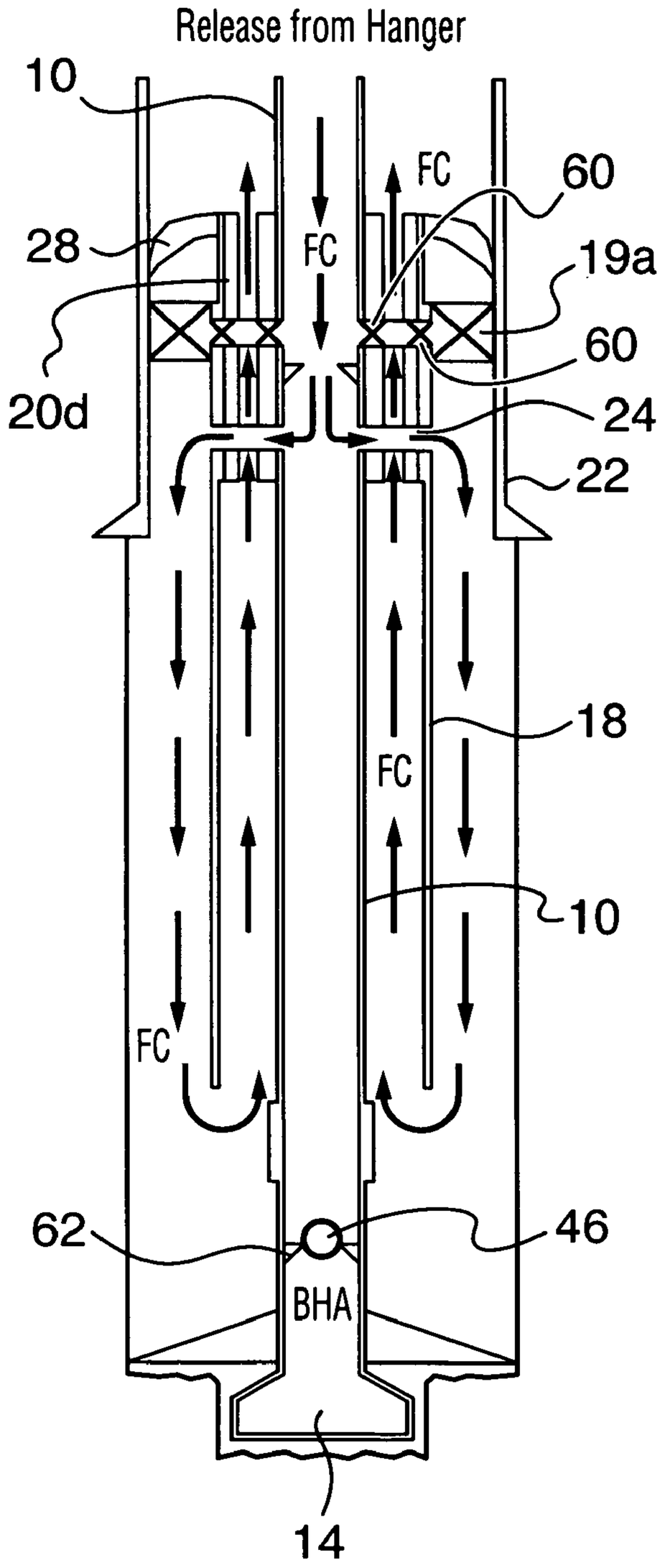

Release from Hanger
10
28
20d
FC
FC
60
60
19a
24
22
18
FC
10
FC
62
BHA
46
14

FIG. 12

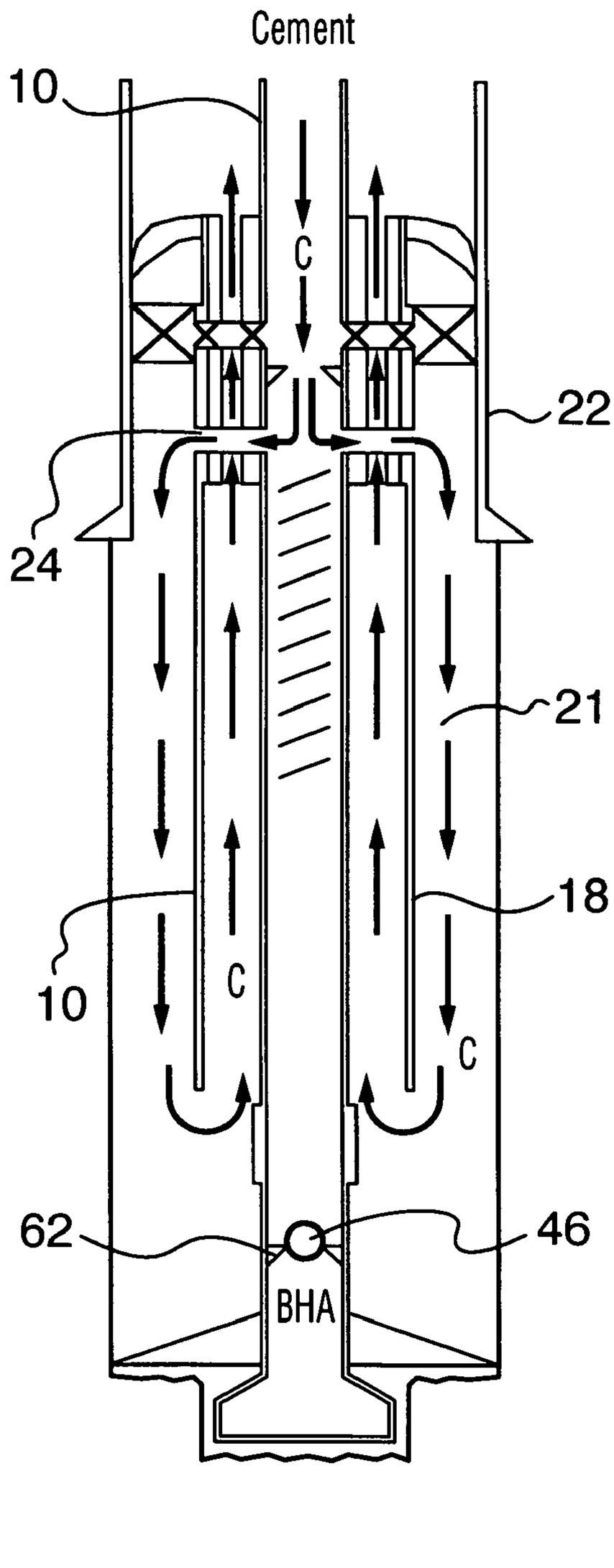

Cement
10
C
22
24
21
18
10
C
C
62
BHA
46

FIG. 13

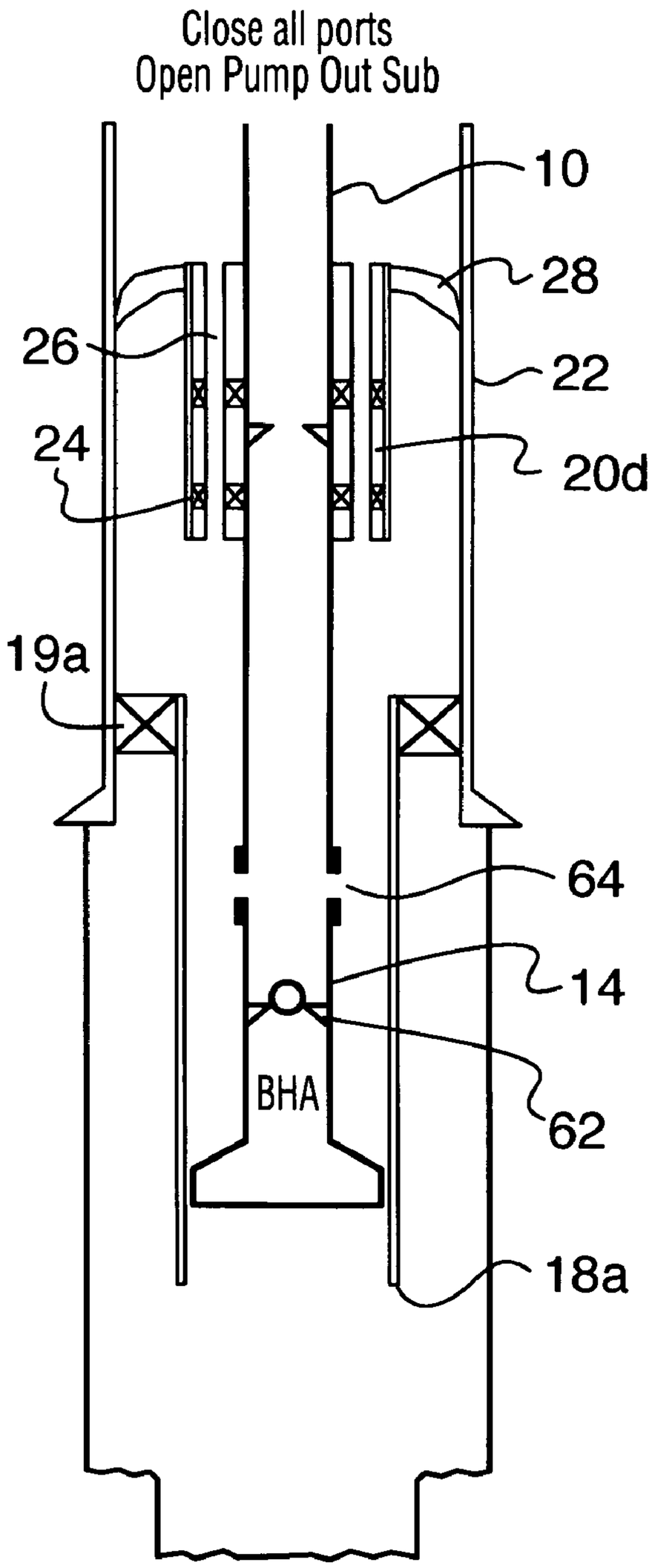

Close all ports
Open Pump Out Sub
10
28
26
22
24
20d
19a
64
14
BHA
62
18a

FIG. 14

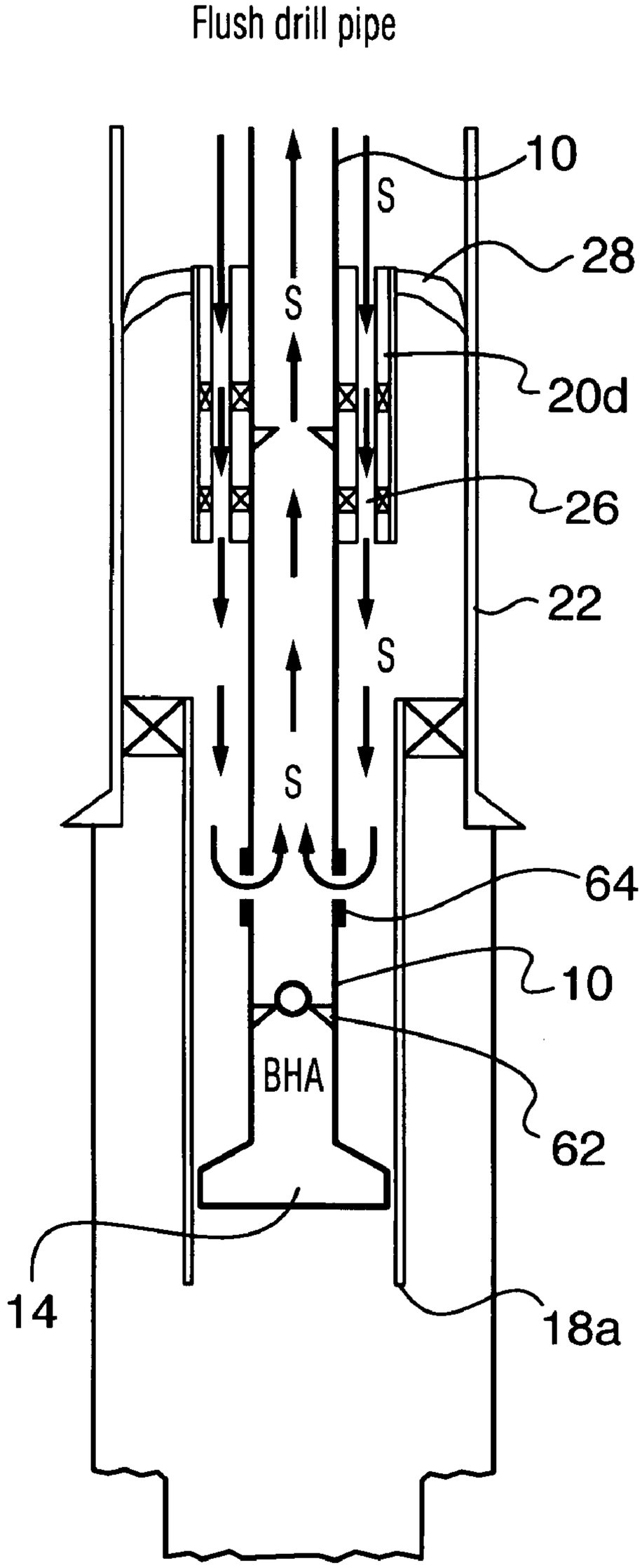

Flush drill pipe
S
10
28
20d
26
22
64
10
BHA
62
14
18a

FIG. 15

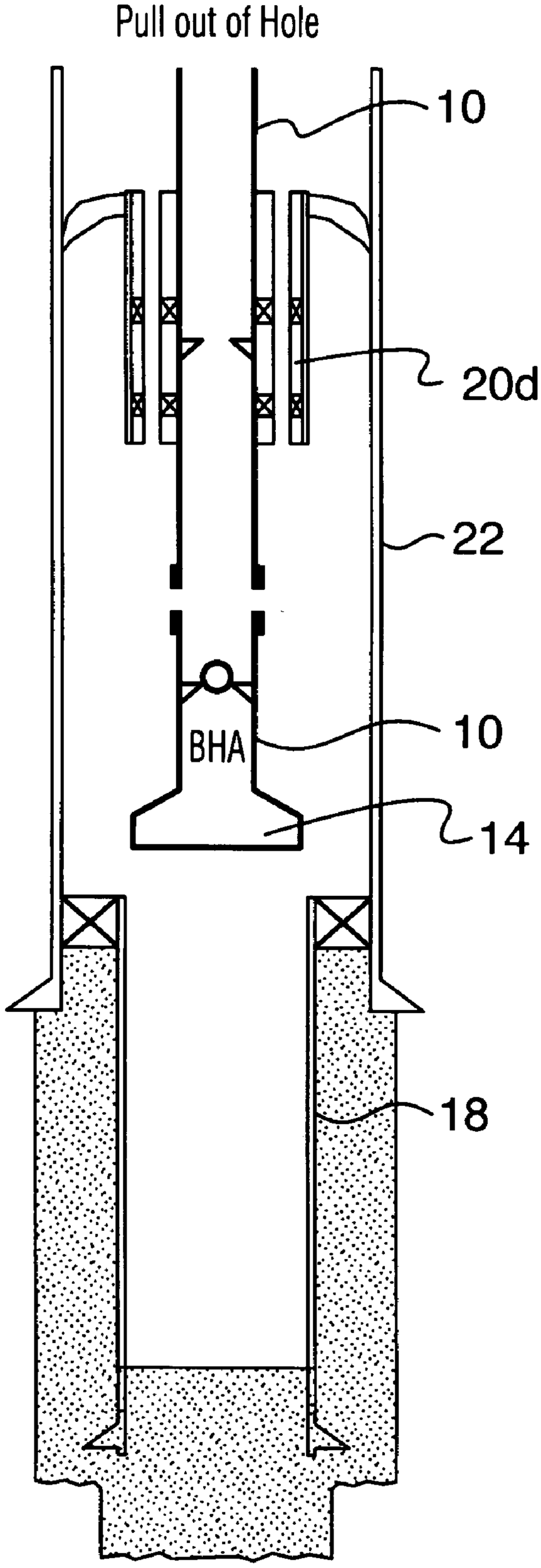



FIG. 16

# METHOD AND APPARATUS FOR DRILLING A BOREHOLE WITH A BOREHOLE LINER

## FIELD OF THE INVENTION

The invention relates to drilling well bores and in particular a method and an apparatus for drilling a wellbore using a borehole liner.

## BACKGROUND OF THE INVENTION

A drilling liner can be carried along behind the pilot bit to line a borehole while it is being drilled. Previously drilling fluid has been circulated down through a drill pipe, through the pilot bit and up the outer annulus between the drilling liner and the borehole wall. In these previous methods, drilling with a liner was often difficult. Pressure exerted on the formation due to a combination of the fluid density and the frictional pressure losses in the small annulus between the liner and the borehole/casing wall may induce fractures in the formation and cause lost circulation.

Alternately, in other methods, the drilling fluid is circulated down through the drill pipe and forced up through the liner by sealing between the liner shoe and the borehole wall. This requires the use of an open hole packer, which may not be desirable.

## SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention, there is provided a borehole drilling apparatus comprising: a drill string including a center bore and a distal end; a bit assembly at the drill string's distal end; a ported sub mounted on the drill string, the ported sub including an upper surface, a lower surface, a bore extending from the upper surface to the lower surface to which the drill string is connected, an axially extending port for providing fluid communication between the lower surface and the upper surface separate from fluid communication with the bore and a lateral port for providing fluid communication between the drill string center bore and an outer surface of the sub between the upper surface and the lower surface, the lateral port being substantially isolated against fluid communication with the axially extending port during operation; and a liner engaging surface encircling the lower surface, the liner engaging surface formed to releasably secure a borehole liner such that the drill string extends through the borehole liner with the bit assembly extending beyond a liner shoe of the liner with an opening between the drill string and the liner.

In accordance with another broad aspect, there is provided a method for drilling a borehole comprising: providing a drill string including a center bore, a distal end, a bit assembly at the distal end; hanging a liner from the drill string, thereby forming an annular space between the drill string and the liner and with the bit assembly extending from a lower end of the liner; positioning the drill string with the liner attached thereto in a borehole such that a second annular space is formed between the liner and the borehole wall; operating the bit assembly to proceed with drilling the borehole; and circulating drilling fluid down through the center bore of the drill string out through the bit assembly and down through the second annular space between the liner and the borehole wall, the drilling fluid returning up through the annular space between the drill string and the liner.



In accordance with another broad aspect of the present invention, there is provided an apparatus for drilling a borehole defined by a borehole wall, the apparatus comprising: a drill string including a center bore and a distal end; a bit assembly at the drill string's distal end; a liner including an upper end and an inner bore and the liner being arranged with the drill string extending through the liner inner bore; a ported sub mounted between the drill string and the liner to support the liner on the drill string, the ported sub including an upper surface, a lower surface about which the liner is connected, a bore extending from the upper surface to the lower surface through which the drill string is connected to the ported sub, an axially extending port for providing fluid communication between the liner inner bore and an upper opening to the upper surface of the sub, a lateral bore providing fluid communication between the drill string center bore and an outer surface of the sub between the upper surface and the lower surface, the lateral port being substantially isolated against fluid communication with the axially extending port during operation; and a seal adjacent the upper end of the liner and selected to seal against fluid flow upwardly about the liner upper end from an annulus formed between the liner and the borehole wall.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic sectional view along a wellbore including a drilling system including a drilling liner and showing a method according to the present invention.

FIG. **2** is a schematic sectional view along a wellbore including another drilling system including a drilling liner and showing another method according to the present invention.

FIG. **3** is a schematic sectional view along a wellbore showing another drilling apparatus and method according to the present invention.

FIG. **4** is a schematic sectional view along a wellbore showing another drilling apparatus and method according to the present invention.

FIG. **5** is a view showing a method that may follow from that of FIG. **4**.

FIG. **6** is a view showing a method that may follow from that of FIG. **5**.

FIG. **7** is a view showing a method that may follow from that of FIG. **6**.

FIG. **8** is a schematic sectional view along a wellbore drilling apparatus.

FIG. **9** is a schematic sectional view along a wellbore showing another drilling method employing the apparatus of FIG. **8**.

FIG. **10** is a view showing a method that may follow from that of FIG. **9**.

FIG. **11** is a view showing a method that may follow from that of FIG. **10**.

FIG. **12** is a view showing a method that may follow from that of FIG. **11**.

FIG. **13** is a view showing a method that may follow from that of FIG. **12**.

FIG. **14** is a view showing a method that may follow from that of FIG. **13**.

FIG. **15** is a view showing a method that may follow from that of FIG. **14**.

FIG. **16** is a view showing a method that may follow from that of FIG. **15**.

## DETAILED DESCRIPTION OF VARIOUS EMBODIMENTS

Drilling with a liner can be accomplished by drilling the liner in place using a drill string **10** formed of, for example, drill pipe or coiled tubing. Drill string **10** may extend from surface to the bottom **12** of the hole. Drill string **10** includes a center bore **13** and can include a bottom hole assembly **17** and a bit assembly **15** for drilling a borehole sized to accommodate passage therethrough of the liner. Drilling assembly **15** may include, for example, a pilot bit **14** and an underreamer **16** (as shown), a bicenter bit, a pilot bit and cutting shoe, etc. As will be appreciated, the bit assembly may be driven by various means such as for example a mud motor in the bottom hole assembly. A liner **18** may be hung onto drill string **10** by a ported sub **20**. Ported sub **20** may be mounted on the drill string, for example about a drill string tubular member or the drill string can be connected thereto, as by threaded connection. Ported sub **20** may include a liner engaging surface for releasably engaging the liner at its up hole end. The surface may encircle the lower end of the sub so that the sub fits in or over the upper end of the liner. The sub may fit sealing against the liner to limit fluid flow therebetween. The liner may be engaged by the sub such that it is hung with an annulus formed between the drill string and the liner, while the lower end of the liner is open about the drill string or ported to allow fluid flow into the drill string/liner annulus.

A liner hanger **19** is provided to support liner **18** within casing liner **22** or against the borehole wall, when it is desired to set the liner.

Ported sub **20** includes ports **26** through which drilling fluid can pass axially through the wellbore between the liner inner bore and the upper surface of the sub, while returning to surface. Ports **26** may be termed axially extending, wherein they may or may not be parallel to the center line of the sub, with reference to its position in the borehole, but permit fluids to pass substantially axially through the well bore. Ports **26** may be sized with consideration as to the volume of drilling fluid that is to be circulated and with consideration as to the size of cuttings that must pass therethrough.

Sub **20** carries a seal **28** such as a packer, a narrow gap seal or swab cups so that fluid is prevented from passing upwardly therepast, thereby substantially preventing drilling fluid from passing out of the annulus about the liner. In one embodiment, the seal may alternately be carried about the upper end of the liner. The seal may be selected with consideration as to the borehole conditions to be encountered. For example, where the borehole is lined with a casing, the seal may be selected to seal against the casing wall.

As drilling commences, fluid in the wellbore tends to be trapped in the annulus **21** about the liner. Drilling fluid provided from surface through drill string **10** flows through the inside (Q**1**) of drill string **10** and out through the pilot bit. Due to the action of seal **28**, fluid trapped in annulus **21** creates a fluid lock forcing drilling fluid to return (Q**2**) up through the annulus between drill string **10** and liner **18**. Fluid passes through ports **26** through sub **20** and returns to surface through the annulus between the casing liner **22** and the drill string.

Referring to FIG. **2**, there is shown another apparatus and method according to the present invention. Drill string **10** extends from surface to the bottom **12** of the hole and can include a bit assembly including, for example, a pilot bit **14** and an under reamer **16** driven and controlled by a bottom hole assembly **17** which may include, for example, a mud motor, MWD, LWD, etc., as desired.

Liner **18** is hung onto drill string **10** by a ported sub **20***a* connected therebetween. Liner **18** carries a liner hanger **19** for wedging the liner in position in the borehole.

As drilling commences, drilling fluid, initially provided through drill string **10**, may be split to both (i) flow F**1** down through the inside of drill string **10** and (ii) flow F**2** down through the annulus about the outside of liner **18**. Fluid then returns F**3** up through the annulus between drill string **10** and liner **18**, passes through ported sub **20***a* and returns to surface through the annulus F**4** between the borehole wall or casing liner **22** and the drill string. The flow F**1** provides that there is enough fluid to drive and lubricate pilot bit **14** and under reamer **16** while flow F**2** acts against a flow of drilling fluid up the annulus between the liner and the borehole. Flow F**2** may force all drilling fluid to pass up between the liner and the drill string. It has been found that flow through the annular space between liner **18** and drill string **10** causes less pressure loss than drilling fluid flow through the annular space between the liner and the borehole wall.

Ported sub **20***a* can include at least one lateral port **24** through which the fluid flow is split. Port **24** allows fluid to be diverted from the drill string inner bore to the annular space about the liner and may, therefore, open between drill string center bore **13** and the outer surface of liner **18**, as shown, or the outer surface of the ported sub where it extends above the liner.

Flow F**2** through port **24** may be controlled or restricted so that only a portion of the flow passes through that port with the remainder continuing down F**1** through center bore **13** to the pilot bit. In one embodiment, a flow restrictor **25** can be installed in port **24** to provide resistance to fluid flow through the port.

Ported sub **20***a* also includes at least one port **26** through which flow F**3** can pass. Ports **26** may be sized to permit cuttings to pass.

Ported sub **20***a* carries a seal **28** such as a packer or swab cups so that fluid is substantially prevented from passing upwardly from the annulus about the liner hanger and substantially prevented from communication between ports **24** and **26**, thereby permitting fluid circulation to be controlled about the liner hanger.

In one embodiment, the drilling may be conducted through a borehole liner, such as a casing liner **22** that may already be cemented in the hole. The drilling may proceed using the above-noted circulation until the liner reaches a casing point, which is a point at which it is desired to set the liner in the borehole. The liner can be any length L in order to achieve a selected extension beyond a lower end **30** of the installed casing.

When the liner reaches casing point, the liner can be hung in the casing string, for example adjacent lower end **30**, by actuation of liner hanger **19**. Ported sub **20***a* and drill string **10**, with attached pilot bit **14** and under reamer **16**, may then be disconnected from the liner and retrieved through the liner and pulled from the well bore. The under reamer, when expanded, cuts a borehole greater than the outer diameter of the liner, but can be collapsed to be withdrawn through the liner.

Thereafter, if desired, the drill string can be reintroduced to the liner for cementing through the drill string. In one embodiment, it may be desirable that the drill string and ported sub **20***a* be removable from the liner at selected times during the drilling process, for example, when it is necessary to replace or repair a bit, under reamer or bottom hole assembly component. In such an embodiment, the ported

sub **20***a* may be reconnectable to the liner and the liner hanger may be reversibly drivable to repeatedly engage, and release from engagement with, the casing.

Referring to FIG. **3**, there is shown another drilling assembly and method. A liner **18** can be drilled in place using a drill string **10** that may be, for example, formed of drill pipe. Drill string **10** extends from surface towards the bottom **12** of the hole and can include drilling tools including, for example, a pilot bit **14**, an under reamer **16** and a bottom hole assembly **17** including a mud motor, MWD and LWD.

The drill pipe joints **10***a* may have a selected outer diameter so that there is a clearance between the inner diameter of the liner and the outer diameter of the drill pipe joints. Such a clearance may be selected to permit passage of drill cuttings and drilling fluid from a drilling operation.

A ported sub **20***a* may be provided including a bore **23** from its upper surface to its lower surface. Drill string **10** can be threadedly connected into bore **23** such that the bore provides communication to the drill string inner bore above and below the sub. Sub **20***a* may include ports **24** open to and extending from bore **23** and ports **26** extending substantially parallel to, but not in communication with, bore **23**.

Liner **18** may be hung onto drill string **10** by the ported sub **20***a*. In so doing, ports **24** may be aligned with ports **24***a* through the liner so that a passage may be opened from bore **23**, that is in communication with the drill string center bore, to the outer surface of liner **18**. As such, a portion of any drilling fluid pumped through drill string can be e jetted through ports **24** and **24***a* into annulus **21**.

Ported sub **20***a* also includes ports **26** through which drilling fluid can pass upwardly out of the liner inner bore. Ports **26** are sized to permit cuttings to pass. Ports **26** are not in fluid communication with ports **24**.

Liner **18** carries a seal **28** such as a packer or swab cups so that fluid is prevented from communicating between ports **24**, **26** through the annulus about the liner, thereby permitting the circulation to be controlled about the liner. Liner **18** also carries a liner hanger **19** for wedging between the liner and the casing **22** when setting the liner in the bore hole.

Stabilizers can be installed to control positioning of the liner and the drill string within the assembly. For example, one or more stabilizers/centralizers **34** may be installed about the liner and/or one or more stabilizers/centralizers **36** may be installed between the drill string and the liner. Of course, these stabilizers/centralizers may be formed to permit fluid flow therepast. Stabilizer/centralizer **36** also permits the passage of drill cuttings. In one embodiment, stabilizer/centralizer **36** may be fluted or ported to permit passage of drill cuttings and fluid.

As drilling commences using the embodiment of FIG. **3**, the drilling fluid is initially provided from surface through drill string **10** and may be split at sub **20***a* to flow down both (i) through the inside (F**1**) of drill string **10** and (ii) through ports **24**, **24***a* into the annulus **21** (F**2**) about the outside of liner **18**. Fluid then returns F**3** up through the annulus between drill string **10** and liner **18**. Fluid passes through ports **26** of sub **20***a* and returns to surface through the annulus F**4** between casing liner **22** and the drill string. Flow F**2** need only be sufficient to force return flow up between the liner and the drill string, rather than between the borehole wall and the liner.

In another embodiment shown in FIG. **4**, a ported sub **20***c* may include a setting tool component **38** to drive the setting of liner hanger **19**. In such an embodiment, the ported sub is positioned between liner **18** and drill string **10**. Ported sub **20***c* accommodates passage therethrough of drill string **10**. Ported sub **20***c* includes at least one port **26** formed to permit fluid communication between the inner bore of liner **18** and an opening on the upper side of a seal **28** about the sub. Drill string **10** and port **26** may pass through various components of sub **20***c* in this embodiment. Sub **20***c* may also, if desired, include a port **24**, possibly including a check valve **27** or restriction, for establishing a reverse circulation down the annulus about liner **18**.

Setting tool component **38** provides one option for setting liner hanger **19**. In the illustrated embodiment, setting tool component **38** may be hydraulically operable by selection of fluid pressures in the drill string. For example, as illustrated, a valve **40** may be positioned in drill string and a fluid passage **42** may be provided in component **38** up hole from valve **40** for communicating fluid to the liner hanger. In particular, valve **40** may include a seat **44** for accepting and creating a seal with a ball **46** (FIG. **5**) launchable from surface when it is desired to generate fluid pressures suitable for operation of the setting tool component. Such generated fluid pressures may be communicated to the liner hanger through passage **42**.

In operation of the embodiment just described, the assembly may be employed for drilling when drill string **10** is open. Drilling fluid may be circulated downhole with a portion passing though port **24** and down through annulus **21** about liner **18** and the remaining fluid flowing through the drill string and past valve **40** and to the bit (not shown). The pressure of the drilling fluid flows cause drilling fluid to be circulated back up through the annulus between liner **18** and drill string **10**, through sub **20***c* and back to surface.

With reference to FIG. **5**, when it is desired to set the liner in the borehole, for example against casing **22**, a ball **46** can be launched, which is sized to pass through drill string **10** and seat in valve **40**. The drill string can then be pressured up P to a desired level to actuate component **38** to set liner hanger **19**. Passage **42** allows for communication of this fluid pressure to the liner hanger.

In an embodiment including a component **38** as described, it may be useful to provide a valve **50** or another mechanism for closing port **24**, where it is included in sub **20***c* so that generation of actuation pressure is not jeopardized by release through port **24**. In addition or alternately, it may be useful to provide a valve or other mechanism in passage **42** which may be selectively openable so that the liner hanger mechanism is not affected by fluid during run in or drilling. In such an embodiment, valve **50** is closed and the valve in passage **42** is opened, before seeking to set the liner hanger by application of fluid pressure.

After setting liner hanger **19**, it may be desirable, as shown in FIG. **6**, to resume access through drill string **10** below valve **40**. As such it may be desirable to select the valve at ball **46** to be removable by expulsion of the ball downwardly, as shown, by destruction of the ball or of the valve seat or by reverse circulation of the ball to surface.

Pressuring up, downhole manipulation, such as axial or rotational movement, etc. can be employed to release at least a portion of sub **20***c* from the liner **18** and liner hanger **19**. If desired, downhole manipulation, such as axial or rotational movement or abutment of the sub or the drill string, may be useful to compress seal **28**, such compression possibly being useful to facilitate pulling the sub and the drill string out of the hole. Such manipulation may be achieved, for example, by setting sub **20***c* down on liner **18** once they have been separated. Once sub **20***c* is released from the liner, it can be tripped with the drill string to surface.

Where it is desired to, thereafter, cement liner **18** in place, a completion string **54** may be run into the hole through casing **22** and liner **18**. As shown in FIG. **7**, completion string **54** may carry a packer **56** sealable between string **54** and liner **18** such that any cement C conveyed through the string may be directed into annulus **21** between the liner and the borehole wall.

Referring to FIG. **8**, in another embodiment a sub **20***d* and other mechanisms may be provided to permit running in, drilling, hanging and cementing the liner in a borehole without tripping of sub **20***d* or the string **10** on which the sub is carried. In such an embodiment, sub **20***d* may include a bore **23** from its upper surface to its lower surface or may accommodate the drill string therethrough. Drill string **10** can be threadedly connected into bore **23** such that the bore provides communication between the drill string inner bore above and below the sub.

A liner **18** may be secured to sub **20***b* to hang down over a length of the drill string with an annulus formed therebetween. An opening is formed by spacing between liner shoe **18***a* and drill string **10** and pilot bit **14** and under reamer **16** (FIG. **10**) extend out from the end of the liner. Liner **18** may carry a hydraulically operable liner hanger/packer **19***a*.

Sub **20***d* may include ports **24** open to and extending from bore **23**. Ports **24** may be closed by manipulation of the sub relative to the liner. Sub **20***d* may also include ports **26** extending substantially parallel to, but not in communication with, bore **23**, and a seal **28** about the sub selected to seal between the sub and a borehole in which the assembly is to be used.

In the embodiment of FIG. **8** the bottom hole assembly may include a pilot bit **14**, an underreamer **16**, a lower drill string bore valve **62**, such as may be provided by a ball catch seat-containing sub and a tubing wall valve **64**, such as may be provided by a pump out sub. As will be appreciated, the bottom hole assembly may also include other components such as, for example, a positive displacement motor, mechanisms for MWD/LWD, centralizers, stabilizers, etc.

Sub **20***d* may further include a setting actuation portion for the liner hanger/packer **19***a* that may include, for example, a ball catch valve **40** positioned in bore **23** and including a seat for accepting a ball **46** (FIG. **11**) launchable from a position above the valve, fluid passages **42** to hanger/packer **19***a* and at least one valve **60** for closing off each of the passages. Passages **42** may be positioned above port **24** and valve **40** may be positioned between passages **42** and ports **24**, so that passages **42** may be hydraulically isolated by valve **40** from ports **24**. In this position, ports **24** may also be accessible below hanger/packer **19***a*.

In a liner drilling operation, the assembly of FIG. **8** may be useful to achieve any or all of (i) drilling in the liner, possibly using reverse circulation of drilling fluid, (ii) hanging the liner by, for example, hydraulically setting slips and packing off the annulus, (iii) releasing the liner, (iv) cementing the liner, by introducing cement to the liner-borehole annulus, (v) holding the cement in the annulus until it sets, to avoid U-tubing of cement slurry, and (vi) clearing out cement slurry from the drill string, and possibly portions of the casing and liner.

In particular, with reference to FIGS. **9** to **16**, an assembly including sub **20***d*, drill string **10** and liner **18** may be made up and run into a borehole through, for example, a casing **22** already installed and cemented in place. During run in, fluid may be circulated and any returns R displaced by seal **28** may be routed through ports **26**. The assembly can be run in until the pilot bit reaches the intermediate casing shoe **22***a*.

At the casing shoe, as shown at FIG. **10**, drilling can commence by operation of pilot bit **14** and underreamer **16**, wherein the shoe is drilled out and drilling may proceed to liner total depth. In so doing, mud can be pumped F**1** down the drill string. A smaller portion, for example in one embodiment about 30%, of the mud can pass F**2** through ports **24** and down the liner/borehole annulus **21**, while the remainder F**3** continues down the string to be jetted through pilot bit **14**. Flows F**2** and F**3** meet at the opening between liner shoe **18***a* and drill string **10** and together return towards surface by flowing F**4** up through the string/liner annulus. Seal **28** isolates flow F**2** separate from flow F**4**.

At total depth, mud can be circulated to clean the hole that has been drilled. Then, as shown in FIG. **11**, ball **46** can be dropped to create a seal at valve **40**, so that hanger/packer **19***a* may be hydraulically set H to hang the liner in the borehole.

With reference to FIG. **12**, sub **20***d* may then be disconnected from liner **18**, as by application of left hand torque to the drill string, and thereby to sub **20***d*, from surface. The drill string may be hoisted slightly to confirm that the liner has been released from the liner. These manipulations may close valves **60**. Fluid pressure may then be increased in drill string such that ball **46** is released and lands in lower drill string bore valve **62** such that flow to pilot bit **14** may be stopped but access to ports **24** is again achieved. Ports **24** may then operate as cementing ports and once circulation is established from surface through ports, a fluid caliper FC can be pumped for cement volume determination.

A spacer and cement slurry C (FIG. **13**), as required, can then be pumped down the drill pipe and out through ports **24**. Such pumping drives the cement slurry C to be reversed down borehole/liner annulus **21** and up through the liner in the liner/string annulus. Cement pumping can be continued until the cement is displaced to a point above sub **20***d*. In one embodiment, for example, the cement may be displaced to a level about 200 ft. above the sub.

As shown in FIG. **14**, while the cement remains hydraulic, drill string **10** and sub **20***d* may be hoisted in the liner to elevate the bottom hole assembly to a position above liner shoe **18***a*. In one embodiment, the bottom hole assembly may be spaced at least 500 feet above liner shoe **18***a*. Ports **24** are closed through the sub. Any openings on liner that correspond to ports **24** are also closed. Tubing wall valve **64** may then be opened, as by pressuring up the drill string or by manipulation. To flush cement from the drill pipe, as shown in FIG. **15**, fluid may be circulated S through tubing wall valve **64**. In the illustrated embodiment, such circulation is conducted in the reverse down through casing **22**, through valve **64** and back up through drill string **10**.

Once the cement has set, the drill string and the sub can be hoisted out of the hole, leaving the liner cemented in place. This is shown in FIG. **16**.

While the foregoing method may be useful with various sized strings and boreholes and various equipment, in one embodiment according to FIGS. **9** to **16**, an 11¾ inch liner may be drilled in, hanged and cemented in a 13⅜ inch casing annulus using a 10⅝ inch pilot bit with a 14 inch cut PDC underreamer, as is available from TESCO Corporation, who is the assignee of the present invention. The pilot bit and underreamer may be driven by a positive displacement motor. Of course, this example is only included for the purpose of illustration and is not intended to be used to limit the invention in any way.

Numerous modifications, variations and adaptations may be made to the particular embodiments described above without departing from the scope of the invention as defined in the claims.

We claim:

**1**. A borehole drilling apparatus comprising: a drill string including a center bore and a distal end; a bit assembly at the drill string's distal end; a ported sub mounted on the drill string, the ported sub including an upper surface, a lower surface, a bore extending from the upper surface to the lower surface to which the drill string is connected, an axially extending port for providing fluid communication between the lower surface and the upper surface separate from fluid communication with the bore and a lateral port for providing fluid communication between the drill string center bore and an outer surface of the sub between the upper surface and the lower surface, the lateral port being substantially isolated against fluid communication with the axially extending port during operation; and a liner engaging surface encircling the lower surface, the liner engaging surface formed to releasably secure a borehole liner such that the drill string extends through the borehole liner with the bit assembly extending beyond a liner shoe of the liner with an opening between the drill string and the liner.

**2**. The borehole drilling apparatus as in claim **1** further comprising a seal extending about the sub operable to create a seal between the upper surface and the liner engaging surface.

**3**. The borehole drilling apparatus as in claim **2** wherein the seal extends about the ported sub to be operable to seal against fluid communication between the axially extending port and the lateral port.

**4**. The borehole drilling apparatus as in claim **3** wherein the lateral port opens between the liner engaging surface and the seal.

**5**. The borehole drilling apparatus as in claim **3** wherein the lateral port opens at the liner engaging surface.

**6**. The borehole drilling apparatus as in claim **1** wherein the lateral port opens at the liner engaging surface.

**7**. The borehole drilling apparatus as in claim **1** wherein the lateral port has a flow volume less than that of the bore such that a lesser fluid flow volume passes through the lateral port than the bore.

**8**. The borehole drilling apparatus as in claim **1** further comprising a valve to control fluid flow through the lateral port.

**9**. The borehole drilling apparatus as in claim **1** wherein the sub further includes a passage opening from the drill string center bore to provide fluid communication with a liner hanger setting component.

**10**. The borehole drilling apparatus as in claim **9** wherein the liner hanger setting component is integral with the sub.

**11**. The borehole drilling apparatus as in claim **9** wherein the sub further includes a valve in the bore, which is closeable to divert fluid pressure to the liner hanger setting component.

**12**. An apparatus for drilling a borehole defined by a borehole wall, the apparatus comprising: a drill string including a center bore and a distal end; a bit assembly at the drill string's distal end; a liner including an upper end and an inner bore and the liner being arranged with the drill string extending through the liner inner bore; a ported sub mounted between the drill string and the liner to support the liner on the drill string, the ported sub including an upper surface, a lower surface about which the liner is connected, a bore extending from the upper surface to the lower surface through which the drill string is connected to the ported sub, an axially extending port for providing fluid communication between the liner inner bore and an upper opening to the upper surface of the sub, a lateral port providing fluid communication between the drill string center bore and an outer surface of the sub between the upper surface and the lower surface, the lateral port being substantially isolated against fluid communication with the axially extending port during operation; and a seal adjacent the upper end of the liner and selected to seal against fluid flow upwardly about the liner upper end from an annulus formed between the liner and the borehole wall.

**13**. The apparatus of claim **12** wherein the drill string is connected by threaded connections into the bore of the ported sub.

**14**. The apparatus of claim **12** wherein the seal extends about the ported sub to seal about the ported sub against fluid communication between the axially extending port and the lateral port.

**15**. The apparatus as in claim **12** wherein the lateral port has a flow volume less than that of the bore such that a lesser fluid flow volume passes through the lateral port than the bore.

**16**. The apparatus as in claim **12** further comprising a valve to control fluid flow through the lateral port.

**17**. The apparatus as in claim **12** wherein the sub further includes a passage opening from the drill string center bore to provide fluid communication with a liner hanger setting component.

**18**. The apparatus as in claim **17** wherein the liner hanger setting component is integral with the sub.

**19**. The apparatus as in claim **17** wherein the sub further includes a valve in the bore, which is closeable to divert fluid pressure to the liner hanger setting component.

**20**. The apparatus as in claim **19** wherein the valve includes a seat to be sealed by a ball launchable from above the valve and the ball and seat are selected to be selectively openable to reopen the bore.

**21**. The apparatus as in claim **19** wherein the passage is positioned above the valve and the valve is positioned above the lateral port.

**22**. The apparatus of claim **12** wherein the seal is mounted on the ported sub.

**23**. The apparatus of claim **12** wherein the seal is mounted about the liner.

**24**. The apparatus of claim **12** further comprising a drill string bore valve in the drill string between the ported sub and the bit assembly.

**25**. The apparatus of claim **12** further comprising a tubing wall valve openable to form an opening through the drill string wall between the ported sub and the bit assembly.

**26**. A method for drilling a borehole comprising: providing a drill string of including a center bore, a distal end, a bit assembly at the distal end; hanging a liner from the drill string, thereby forming an annular space between the drill string and the liner and with the bit assembly extending from a lower end of the liner; positioning the drill string with the liner attached thereto in a borehole such that a second annular space is formed between the liner and the borehole wall; operating the bit assembly to proceed with drilling the borehole; and circulating drilling fluid down through the center bore of the drill string out through the bit assembly and down through the second annular space between the liner and the borehole wall, the drilling fluid returning up through the annular space between the drill string and the liner.

27. The method of claim 26 wherein the drilling fluid is circulated down through the second annular space from a port extending from the drill string that opens into the second annular space.

28. The method of claim 26 wherein after a selected depth is reached, the method further comprises hanging the liner in the borehole, disconnecting the drill string from the liner and pulling the drill string to surface, leaving the liner in the borehole.

29. The method of claim 28 the method further comprising inserting a cementing string and pumping cement through the cementing string to fill the second annular space.

30. The method of claim 26 wherein after a selected depth is reached, the method further comprises pumping cement down through the second annular space and up through the annular space between the drill string and the liner.

31. The method of claim 30 further comprising hoisting the drill string such that the bit assembly is positioned above the liner shoe and circulating fluid through the drill string to clear cement from the drill string.

32. The method of claim 26 further comprising providing a ported sub mounted on the drill string, the ported sub including an upper surface, a lower surface, a bore extending from the upper surface to the lower surface to which the drill string is connected such that the bore is in communication with the drill string center bore, an axially extending port for providing fluid communication between the lower surface and the upper surface but isolated from fluid communication with the bore; and a liner engaging surface encircling the lower surface, the liner engaging surface formed to releasably engage the liner for hanging on the drill string.

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